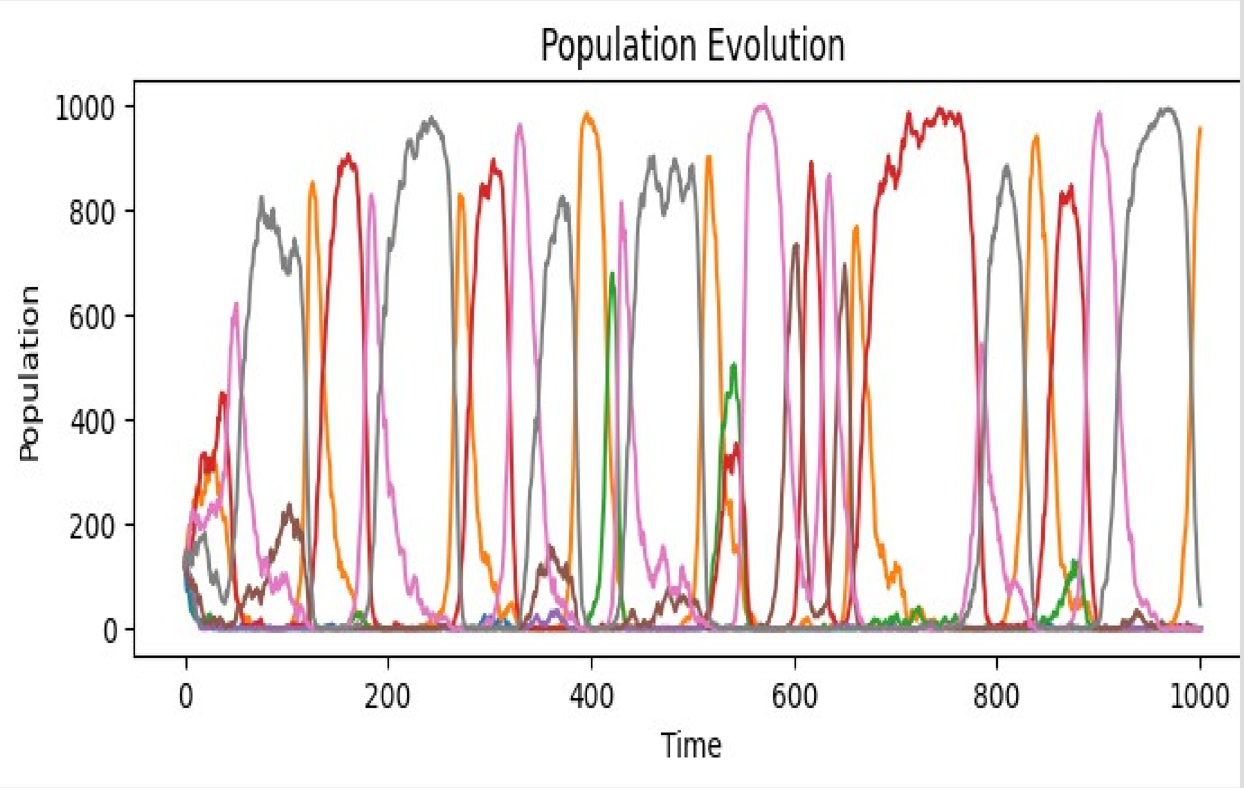
Stochastic Modelling Project

By Miguel Pinel Martínez



Evil green beards: Tag recognition can also be used to withhold cooperation in structured population

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Evil green beards: Tag recognition can also be used to withhold cooperation in structured populations

Julián García, Matthijs van Veelen, Arne Traulsen

HIGHLIGHTS

- We study the interaction between two mechanisms for the evolution of cooperation.
- We show that tag recognition and population structure interact in a non-trivial way.
- Low assortment leads to cycles with periods of tag based cooperation and defection.
- High assortment leads to cycles where tags are used to undermine cooperation.
- High assortment does not lead to indiscriminate cooperation if tags are available.

ARTICLE INFO

ABSTRACT

1. Introduction

Authors of the paper:

- **Julián García**
- **Matthijs van Veelen**
- **Arne Traulsen**

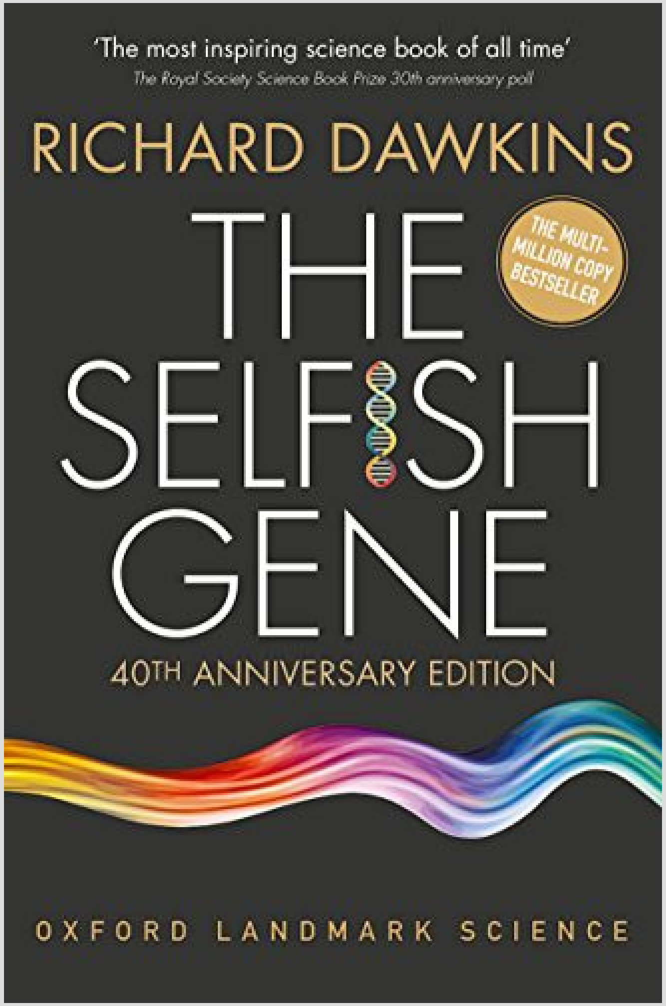
This project has been made with the help of **Matthijs van Veelen** who has had no problem explaining in detail the particularities of these models

Is altruism evolutionarily viable?

One of the most interesting biological question is: “Is altruism viable following Darwinian evolution?”.

If the evolution is the survival of the fittest, can an individual with a altruistic behaviour survive?

Understanding in this context altruism as helping another member of the population by doing something inherently negative for yourself



For more information recommended literature

Prisioner's dilemma

$$\mathbf{P}_1 = \begin{array}{c|cc} & D & C \\ \hline D & \multicolumn{2}{c}{\multirow{2}{*}{$\begin{pmatrix} 0 & b \\ -c & b-c \end{pmatrix}$}} \\ C & & \end{array}$$

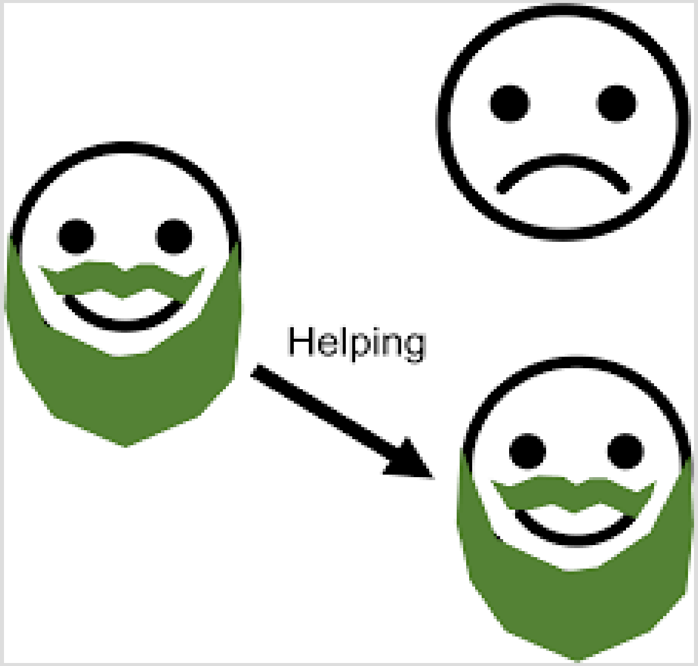
$$b > c > 0$$

$$b/c = 2$$

We are going to simulate interactions between individuals folllowing a standard prisioner's dilemma.

As it is usual both cooperating give the best overall outcome but is an inestable state, being both defectors is the Nash equilibrium even though is overall worst.

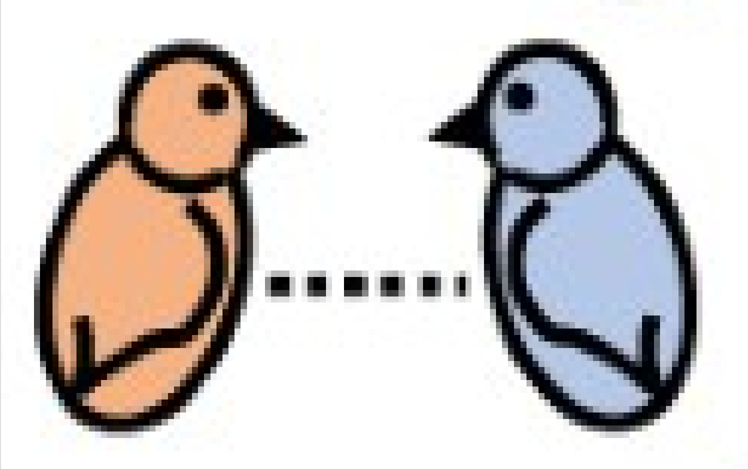
Green beard effect



It would be beneficial for the cooperators to have a way of distinguish other cooperators from defectors.

This is the green beards effect, all the individuals that have the strategy of cooperate also have a distinguish factor, like a green beard, so that all the green beards will cooperate with each others, but not with the rest.

Tags recognition



In this project each individual will have a tag that represent a way for the rest of the population to know to which group it belongs. We are going to focus on only two different tags, but the results are generalizable to k tags.

Each individual will be represented as a tag(0 or 1) and the strategies it follow against each of the tags, for example [0,(C,C)] will be an indiscriminate cooperator of tag 0

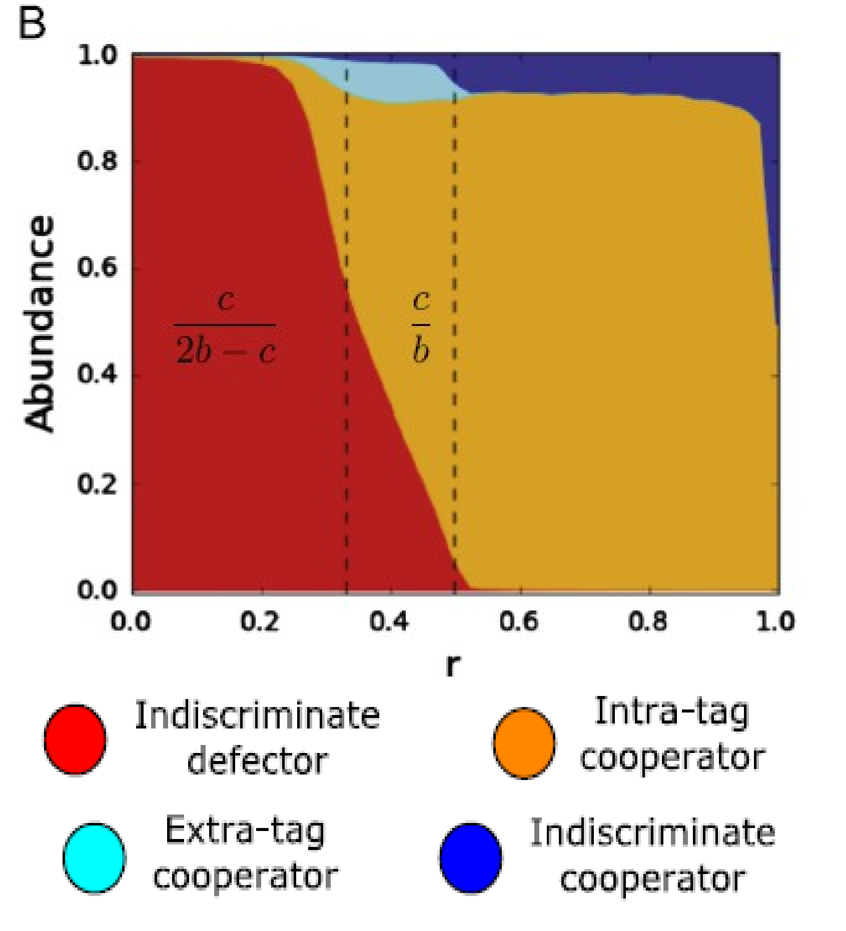
Assortment cause by population structure

The main different from this paper to previous about the green beard effect is the population structure.

In this context we understand the population structure as the increase in the probability of encountering an individual with your same strategy.

Our focus will be to find the predominant strategy depending of the level of population structure

Results of the paper :



This is the main result of the paper that we will try to replicate.

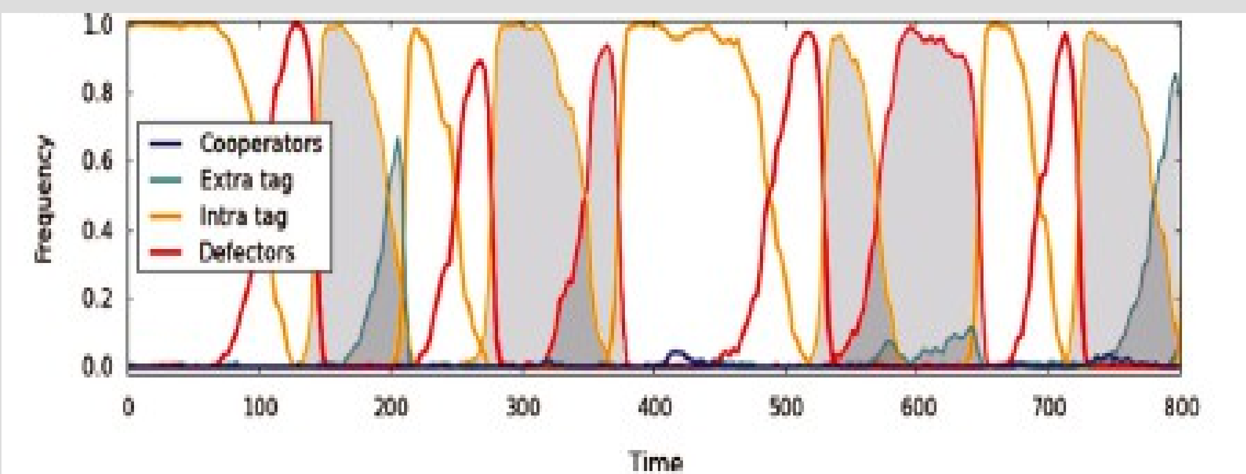
Base on the level of assortment there are three main scenarios: if the level is very low the indiscriminate defector is the best strategy, as the level increase the intra-tag cooperator become the dominant strategy and start the usual green beard cycles, lastly if the level is too high then they start the evil green beard cycles

Normal green beard cycle

Indiscriminate defector of tag A

Intra-tag cooperator of tag A

Intra-tag cooperator of tag B



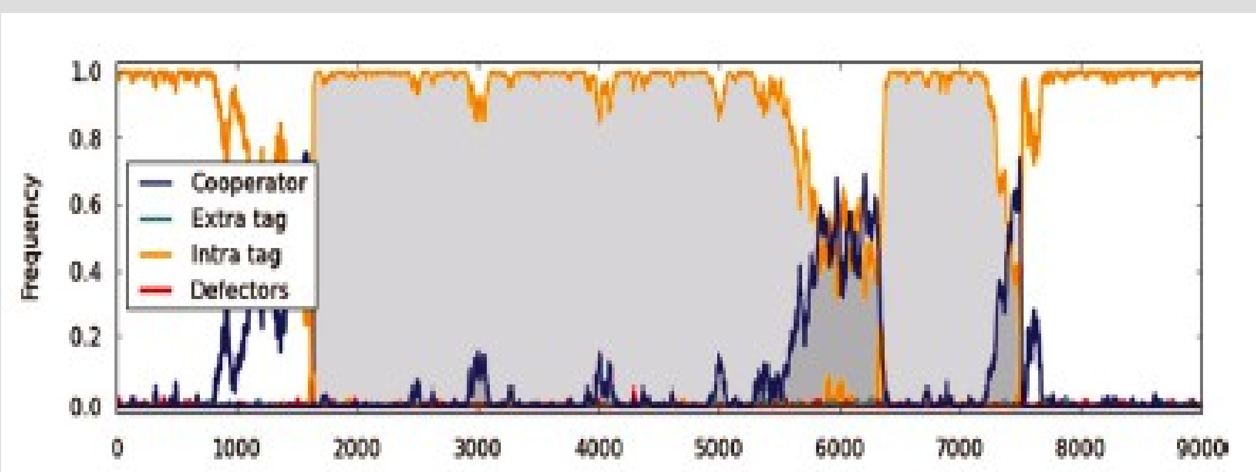
The normal green beard cycle is as follow: it start with a high number of cooperators of one tag, they get invaded by false green beards, defectors of the same tag, when there are a lot of defectors in that tag then the best strategy is to be an intra-tag cooperator of the other tag, therefore starting again the cycle

Evil green beard cycle

Indiscriminate cooperators of tag A

Intra-tag cooperator of tag A

Intra-tag cooperator of tag B



The evil green beard cycle is as follow: it start with a high number of intra-tag cooperators of one tag, they drift into a mix with indiscriminate cooperators, when there are enough indiscriminate cooperators in that tag then the best strategy is to be an intra-tag cooperator of the other tag, therefore starting again the cycle.

The model:
Moran Process

Fitness calculation	Parents selection	Random Mutation
First we calculate the fitness advantages of each individual	We choose the parents for the next generation randomly with probabilities proportional of the fitness of each individual	We change a small percentage of the population to a random strategy

Intensity of selection

The intensity of selection is a parameter that determine how strongly does the different in fitness affects the parents selection.

Let be β our intensity of selection.
If f_i is the fitness of the individual i then the probability of being chosen as a parent is :

$$\mathcal{P}(i) = \frac{e^{\beta f_i}}{\Sigma_j e^{\beta f_j}}$$

Exogenous assortment: Parameter r

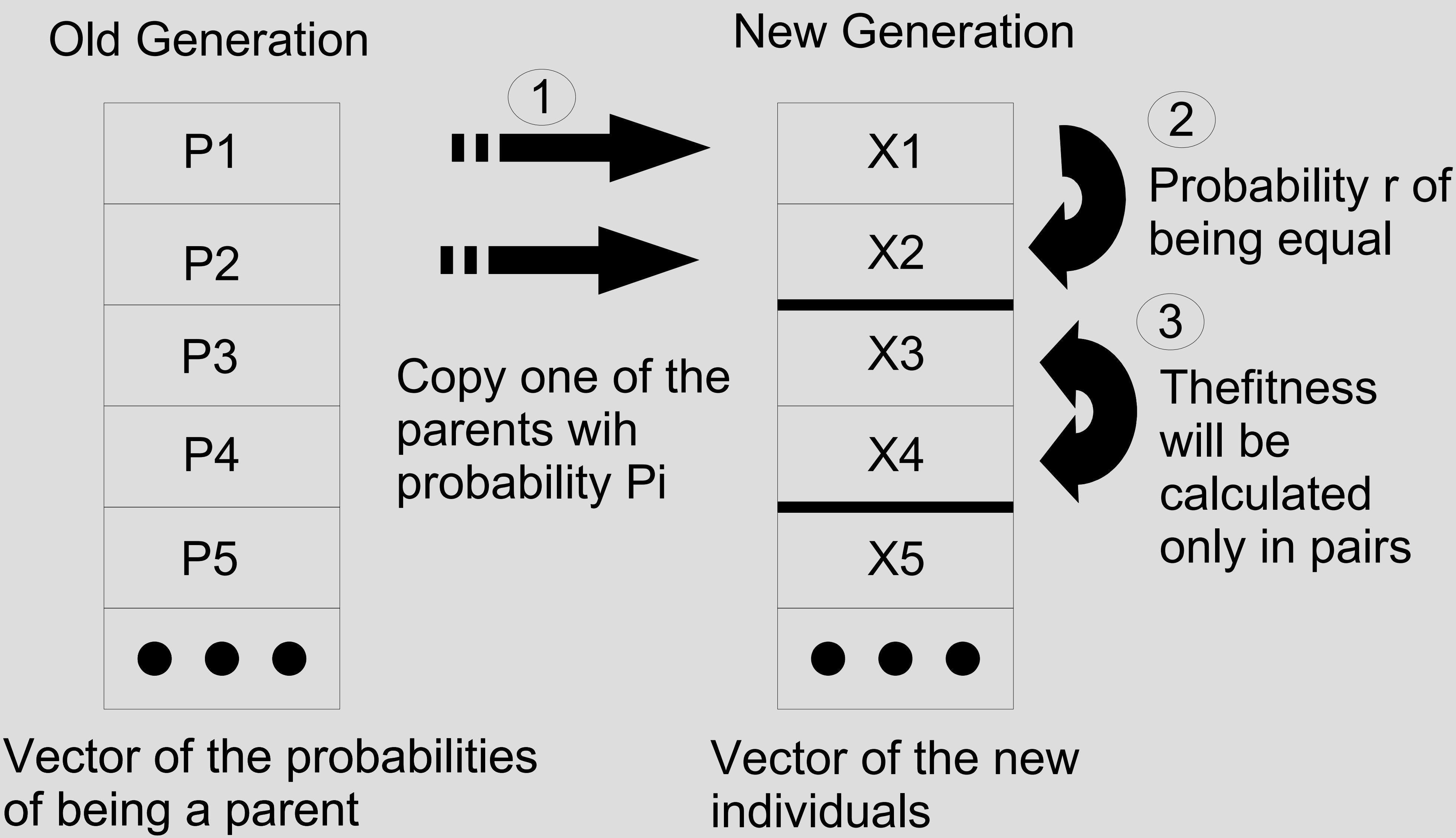
We are going to consider a level of structure in the population, reflected in the parameter r which is going to represent the extra probability of an individual to play against the same strategy as itself

$$\mathcal{P}(A|A) = (1-r)f(A) + r$$

$\mathcal{P}(A|A)$ is the probability of encounter an individual with strategy A while having the strategy A

$f(A)$ is the frequency of the strategy A

Exogenous assortment: Parameter r (2)



Results of the simulations: Parameters

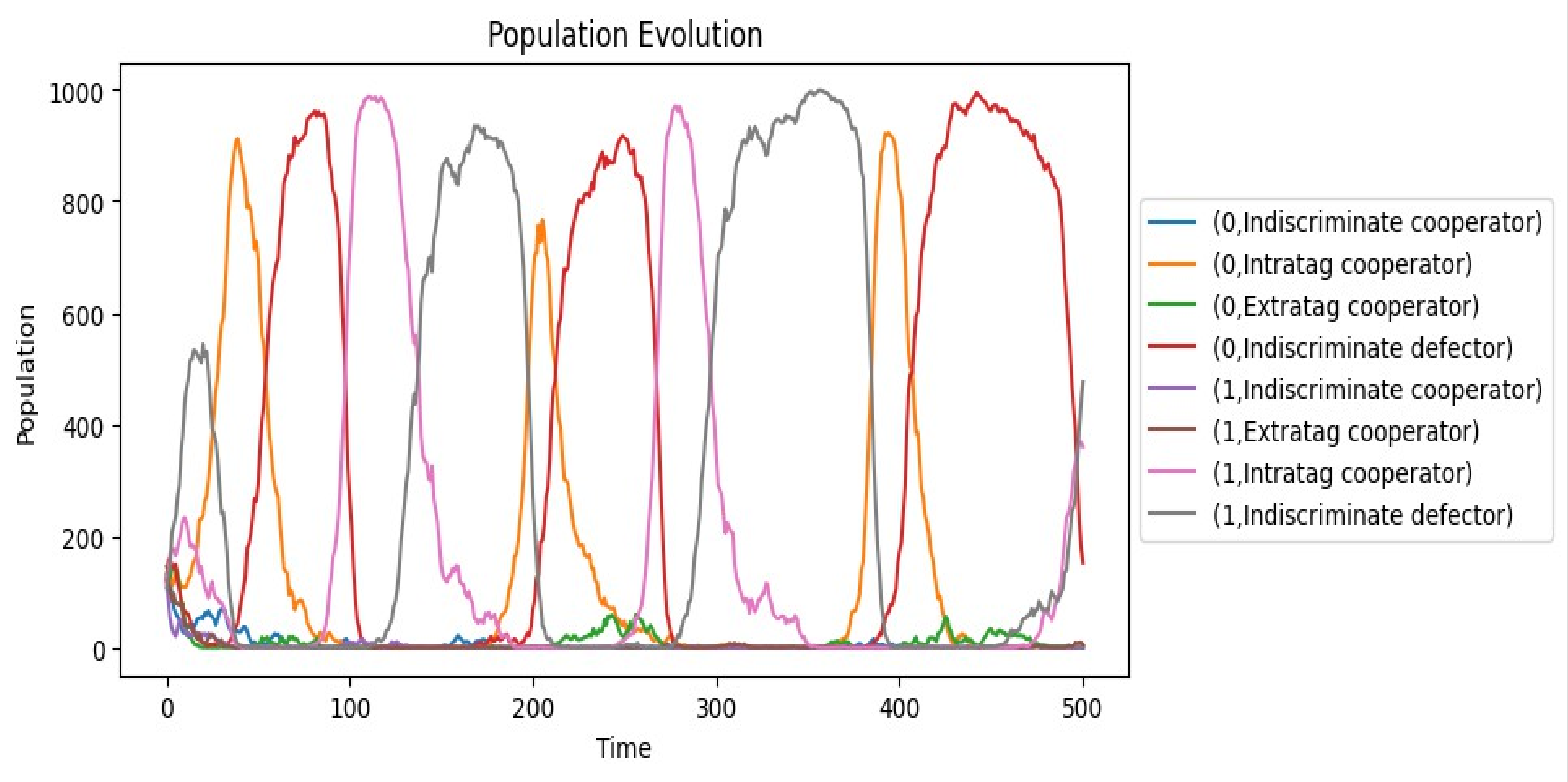
The model used has been created using Google Colab in python using the following parameters:

- Population size: 1000
- Mutation chance: 0.001
- Intensity of selection: 0.5

The main different with the simulations of the paper is that our number of generations is quite lower from the one million used in the original paper.

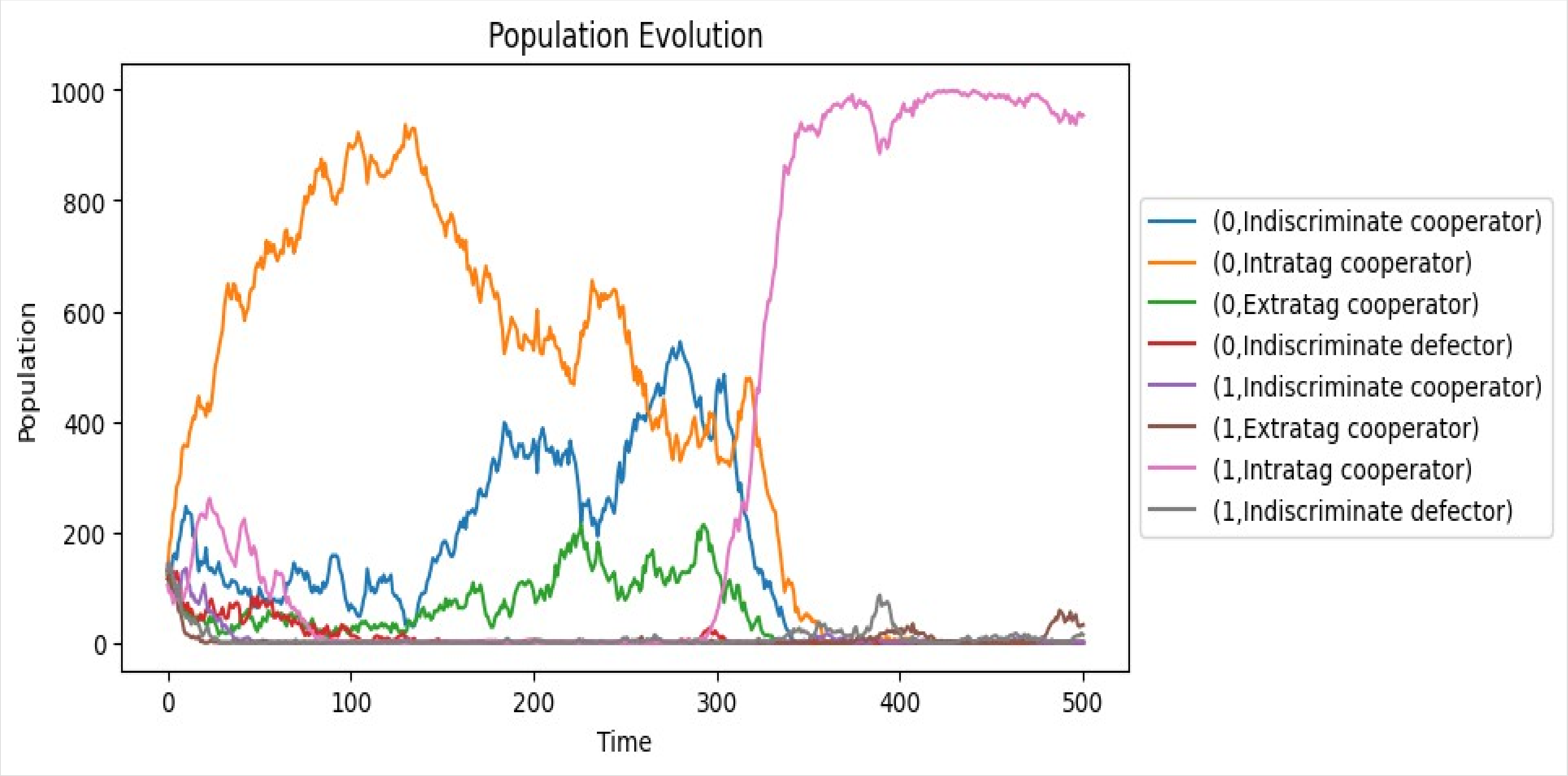
Results of the simulations: Normal green beard cycle

Simulation of 500 generations with r = 0.4



Results of the simulations: Evil green beard cycle (1)

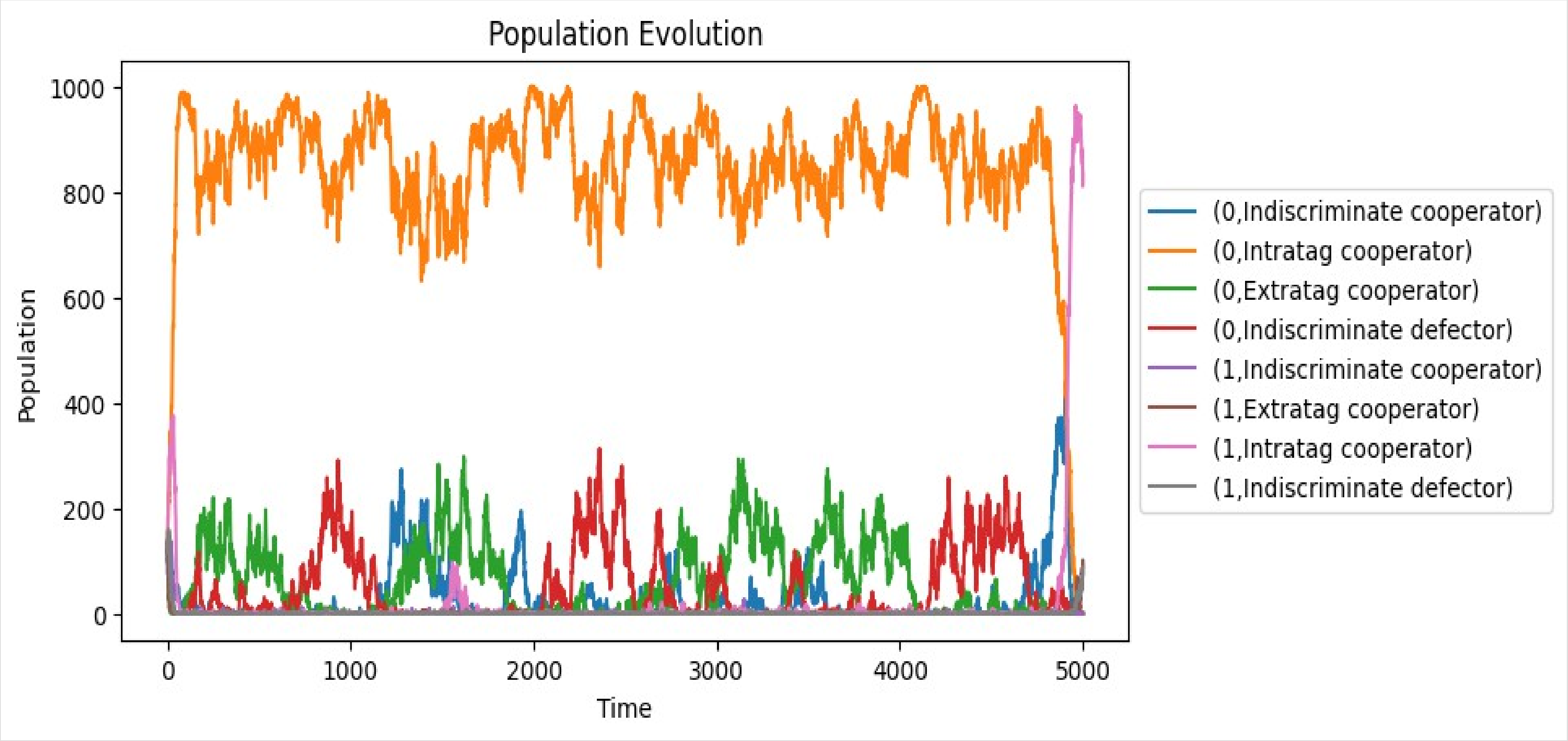
Simulation of 500 generations with r = 0.6



Results of the simulations: Evil green beard cycle (2)

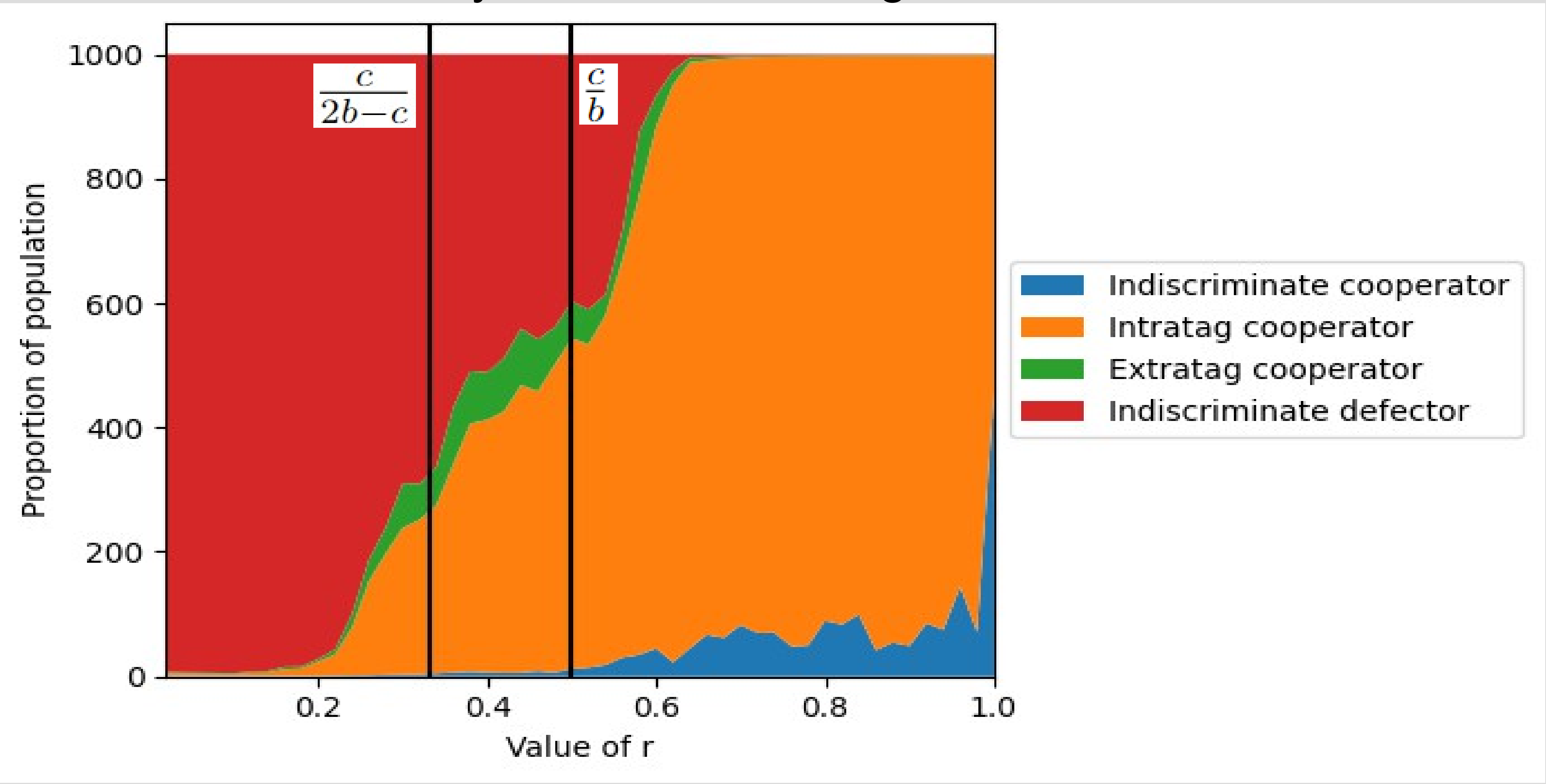
The evil green beard cycle can be have long period of time without changing tag

Simulation of 5000 generations with r = 0.6



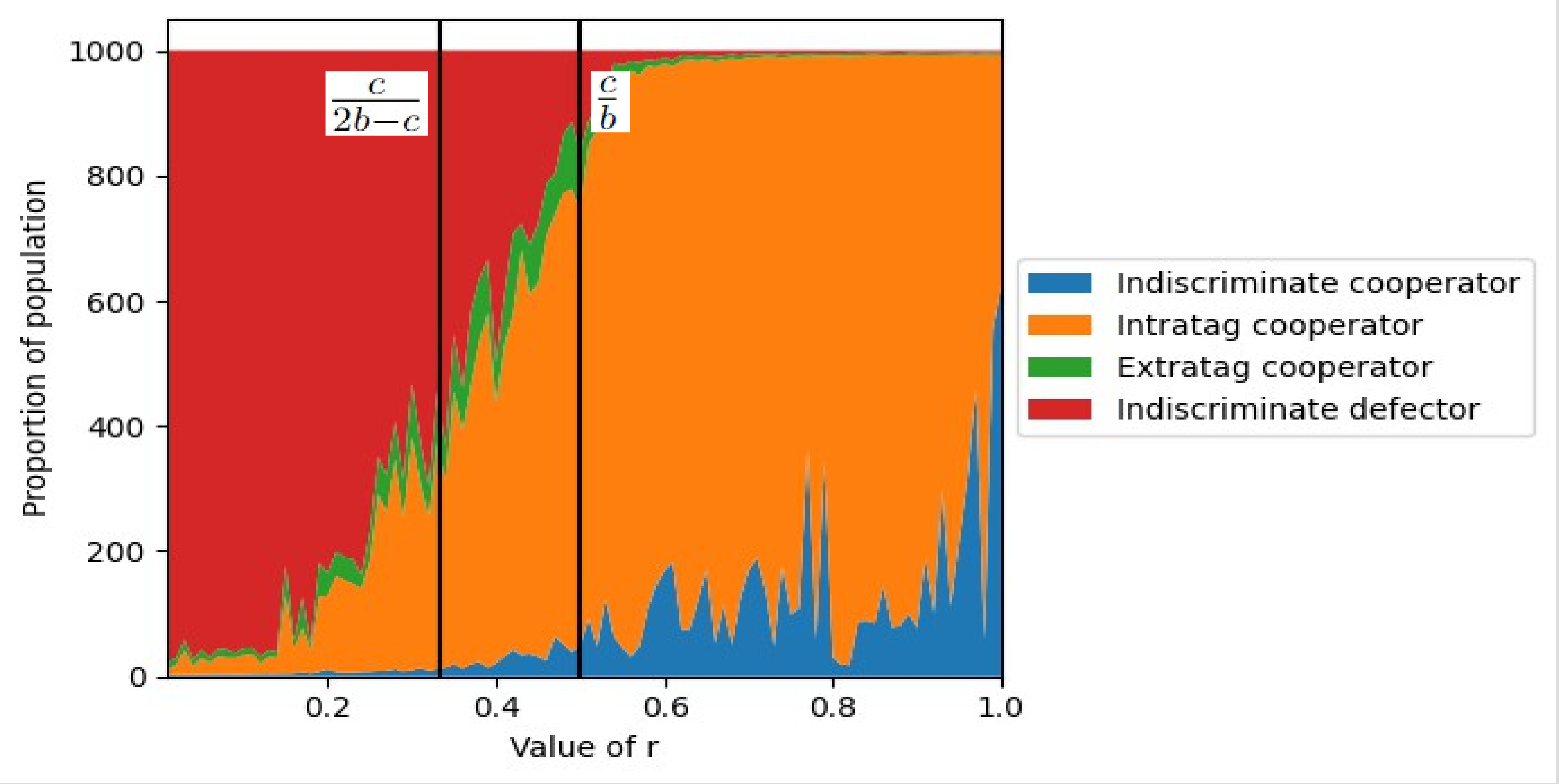
Results of the simulations: Strategies depending of r (1)

100 simulations of 10000 generations each varying r
With intensity of selection being 0.5



Results of the simulations: Strategies depending of r (2)

With intensity of selection being 0.1



Conclusions

- The results of the paper seems plausible because they coincide with the results of our simulations.
- With high population structure cooperation is viable, but indiscriminate cooperation is never the best strategy.
- At any assorment level we can find changes in which tag is the predominant one.